Kidney International, Vol. 1 (1972), p. 182–189

Estimation of weight loss during coil dialysis

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Estimation of weight loss during coil dialysis. The ultrafiltration rate (UF, ml/min) during hemodialysis should be a function of the mean net hydrostatic and effective osmotic transmembrane pressure gradients between blood and dialysate. At constant perfusate temperature and protein concentration, UF collected directly from coils perfused *in vitro* without dialysate has been shown to be a linear function of mean coil pressure (MCP: inlet plus outlet pressure/2). Other variables such as hematocrit and blood flow rate do not affect this relationship. The deviation from this relationship due to dialysate hydrostatic pressure and blood-dialysate effective osmotic gradients during clinical dialysis has not been assessed. To determine if such deviation is minimal and if weight loss during clinical dialysis could be predicted from MCP, net weight (wt) loss (fasting dialysis wt loss minus basal overnight measured wt loss; g/min) was compared to UF collected directly from the same coil at identical MCP in 100 clinical dialysis studies using six coil types (EX-03, EX-01, UF-145, UF-100 cupraphane, UF-100 cellophane, UF-60 pediatric). For each coil type, the characteristic *in vitro* linear relationship of UF to MCP, the coil resistance under standard conditions as a relative index of expected MCP range, and the effects of dialysate flow on coil resistance were determined.

The studies show that under comparable conditions, different coil types function at different MCP as a function of coil resistance and manifest a characteristic linear relationship of directly measured UF to MCP. For non-encased coils observed net wt loss and predicted net wt loss from directly measured UF were essentially identical. For encased EX coils, net wt loss was less than predicted. This most likely reflects effects of relatively higher dialysate hydrostatic pressure in EX coils. Accordingly, only the resistance of EX coils was increased by dialysate flow, and differences between predicted and observed weight losses were eliminated with negative pressure dialysate flow. Arterial-dialysate osmolality ranged from -3 to $+56$ mOsm/kg H_2O and had no apparent effect on wt loss. Correction for relatively constant differences of predicted and observed wt loss in EX coils permits accurate prediction of wt loss from MCP for all coils studies.

Calcul de la perte de poids pendant la dialyse sur bobine. Pendant l'hémodialyse l'ultrafiltration (UF, ml/min) devrait être une fonction des gradients moyens nets de pressions hydrostatique et osmotique existant entre le sang et la solution de dialyse. Pour une température et une concentration de proteines constantes du liquide de perfusion, l'UF, receuilli directement de bobines perfusée *in vitro* sans liquide de dialyse est une fonction linéaire de la pression moyenne de la bobine (MCP: pression à l'entrée plus pression à la sortie/2). D'autres variables, tels l'hématocrite et le debit sanguin, ne modifient pas cette relation. L'influence sur cette relation de la pression hydrostatique de la solution de dialyse et des gradients osmotiques efficaces entre le sang et la solution de dialyse n'a pas été étudiée. Pour le caractère minime de cette influence et voir si la perte de poids pendant la dialyse clinique pouvait être prédite à partir de la MCP, nous avons comparé le perte nette de poids (wt) (perte de poids à jeûn après dialyse moins perte de poids spontanée pendant la nuit; g/min) à l'UF receuilli directement de la même bobine à une MCP identique. L'étude a porté sur 100 dialyses cliniques faites avec six types de bobines (EX-03, EX-01, UF-145, UF-100 cupraphane, UF-100 cellophane, UF-60 pediatrique). Pour chaque type de bobines ont été étudiés: la relation linéaire charactéristique existant *in vitro* l'UF et la MCP; la résistance de la bobine déterminée dans des conditions standard index relatif de l'écart prévisible des MCP; et les effets du debic de la solution de dialyse sur la résistance de bobine.

Les résultats montrent que, dans des conditions comparables, divers types de bobines fonctionnent à des MCP différentes, en relation avec leurs résistances. Une relation linéaire charactéristique existe entre l'UF, mesurée directement, et la MCP. Pour les bobines non-enboitées, la perte nette de poids observée et la perte de poids prédite par la mesure directe de l'UF étaient identiques. Pour les bobines Exemboitées, la perte observée était moindre que la perte prédite. Ceci résulte vraisemblablement des ettets d'une plus grande pression hydrostatique de la solution de dialyse dans les bobines EX. Pour cette raison seule la résistance des bobines EX est accrue par le écoulement de la solution de dialyse et les différences entre les pertes de poids prédites et observées sont éliminées lorsque la liquide de dialyse s'écoule à ression négative. La différence d'osmolalité entre le sang arterial et la solution de dialyse variait de -3 à $+56$ mOsm/kg H_2O et n'avait pas d'influence apparente sur la perte de poids. Pour toutes les bobines EX etudiées la perte de poids peut être prédite avec précision à partir du MCP si l'on tieat compte des différences relativement constantes entre perte de poids prédites et observées.

Received for publication July 13, 1971;
accepted in revised form October 7, 1971.

It has been customary to attempt to regulate the rate of ultrafiltration and weight loss during coil hemodialysis by adjusting the outlet pressure with a venous outflow clamp. Since blood flow rate, hematocrit, serum protein concentration, temperature, and coil resistance all affect the pressure drop along the blood path, inlet pressure and, therefore, mean coil pressure (inlet pressure + outlet pressure/2), can vary markedly at fixed outlet pressures. *In vitro* studies have shown that ultrafiltration rate correlates highly with mean coil pressure but relatively poorly with outlet pressure [1]. It is not surprising that attempts to estimate and control ultrafiltration and weight loss during clinical coil dialysis by regulating the outlet pressure alone have often produced inaccurate results.

The present study was designed to determine whether the regulation of mean coil pressure (MCP) during coil hemodialysis can permit precise clinical prediction of ultrafiltration and weight loss. Since ultrafiltration rate is a function of mean net hydrostatic and effective osmotic transmembrane pressure gradients between blood and dialysate, ultrafiltration rates measured directly from coils *in vitro* without dialysate might differ from values during clinical dialysis at identical mean coil pressure. The characteristic relationship of directly measured ultrafiltration rate to mean coil pressure and the variability of that relationship was determined for six types of dialysis coils. Dialysis-induced weight loss and directly determined ultrafiltration rate were compared with measurements of both values during dialysis from each of the 37 coils studied.

These studies show that regulation of mean coil pressure during clinical hemodialysis enables precise estimation of ultrafiltration and weight loss. Analysis of the relationship of ultrafiltration rate to mean coil pressure and the factors which affect that relationship in each coil type permits a better understanding of the respective differences in clinical performance than have previous comparisons of dialysis coils where all these variables were not controlled.

Methods

The relationship of ultrafiltration rate to mean coil pressure was measured directly. Thirty-seven separate coils (seven UF-145, one UF-60 pediatric, six UF-100 cupraphane, four UF-100 cellophane [Travenol Laboratories Inc., Morton Grove, Illinois], and nine EX-03 and ten EX-01 [Extracorporeal Medical Specialties, Inc., Church Road, New Jersey]) were used during 37 dialyses in ten patients with chronic renal failure. The specifications of these coil types are outlined in Table 1. One hundred net weight loss determinations were performed, representing two to three such measurements per coil. Mean coil resistance was determined for each coil type under standard laboratory conditions to examine its variation in different coil types and its relationship to mean coil pressure.

Direct determination of the relationship of ultrafiltration rate to mean coil pressure in the absence of dialysate flow. During every dialysis, coil inlet and outlet pressures (mm Hg) were monitored with anaeroid manometers. Manometers were either placed at the top of each coil or pressures were corrected to that level. Dialyses were performed with a Travenol Recirculating Single Pass Dialyzer (except in six special studies where dialysate flow through the coil was induced by negative pressure) and a Sarns standard roller-type blood pump. With Ultra-Flo coils, pericoil cuff pressure was set at 150 mm Hg following a saline prime. During each dialysis the coil and its

Table 1. Comparative coil characteristics

	UF-145 cellophane	UF-100 cupraphane	UF-100 cellophane	UF-60 cupraphane	EX-01 cupraphane	EX-03 cupraphane
Membrane thickness (microns)	25	18	25	18	18	18
Number of tubes	2	2	2	2	1	1
Tube length (cm)	820	570	580	330	350	350
Tube width (cm)	4.5	4.5	4.5	4.5	10	12
Membrane surface area (cm^2)	15,000	10,000	10,000	6,000	7,000	8,400

cannister were lifted from the dialysate reservoir and placed atop a graduate cylinder while being perfused continuously from the patient. Mean coil pressure was varied by adjusting outlet pressure and/or blood flow rate. Ultrafiltration rate was measured directly during at least three periods with different mean coil pressure settings by collecting ultrafiltration over intervals of five to ten minutes as previously described [1]. Following these direct measurements, the coil and its cannister were returned to the dialysate reservoir and hemodialysis was resumed. The coil was usually out of the dialysate reservoir for no longer than 30 minutes and no known effects resulted from this maneuver.

The determined relationship between ultrafiltration rate and mean coil pressure was used to predict the net weight loss during a dialysis period at a given mean coil pressure using the identical coil. One milliliter of ultrafiltrate was considered to weigh one gram and slight errors in this assumption due to solute content and deviation from standard conditions were accepted.

Determination and relationship of net weight loss to mean coil pressure. On the evening preceding the day of hemodialysis, patients were admitted to the University of Missouri Clinical Research Center. A fasting overnight basal weight loss rate in g/min was measured with a metabolic bed scale. Any stools or urine collections and administered medications during the determination of fasting weight loss were weighed, and the fasting weight loss was corrected to represent only net unmeasured losses. Dialysis was performed with the patient in the same bed under the same environmental conditions. During each dialysis the rate of fasting weight loss (g/min) was determined over two to three periods usually of 60 to 120 minutes duration. During each such period, the mean coil pressure was kept constant.

Samples of the patient's arterial blood and dialysate inflow were obtained for determinations of osmolality at the start of 73 of the 100 dialysis weight loss periods. During these studies, dialysate flow into the recirculating reservoir was maintained at 350 to 400 ml/min.

To evaluate further the effect of dialysate pressure on rigidly encased coils, six dialyses were performed with dialysate pulled by negative pressure through two EX-03 and four EX-01 coils. This was accomplished by placing the EX coils upright over the dialysate drain site in the original Travenol 100 liter tank while dialysate was circulated. The procedure described above was then followed.

Comparison of coil resistances under comparable conditions. Coil resistances vary markedly with alterations in coil design as do mean coil pressures at comparable outlet pressures and perfusion rates. To demonstrate this the resistances of 20 coils (five UF-145, five EX-03, four EX-01, two UF-60 pediatric, two UF-100 cupraphane, and two UF-100 cellophane) were determined under identical conditions. All coils were perfused with 0.9% sodium chloride at 25°C, a flow rate of 200 ml/min, and an outlet pressure adjusted to 200 mm Hg. The coil inlet pressure was measured under these conditions and its resistance calculated.

During dialysis, the effects of dialysate circulation on coil resistance were determined under constant blood flow by monitoring mean inlet pressure and outlet pressure with the recirculating dialysate pump first on and then off.

Coil perfusion rates (ml/min) were measured directly in the laboratory and from previous pump calibrations during clinical dialysis.

Determinations and calculations. Osmolality (mOsm/kg H_2O) was determined by freezing point depression with an Osmette-S Automatic Osmometer. Net weight loss rate during dialysis study periods was calculated as observed weight loss rate (g/min) minus overnight basal weight loss rate (g/min). Observed net weight loss (g/min) minus predicted net weight loss (g/min) was calculated for every weighing period. Coil resistance (mm Hg × ml/min) was calculated as (mean inlet pressure minus outlet pressure)/perfusion rate.

Results

Direct determination of the relationship of ultrafiltration rate to mean coil pressure in the absence of dialysate flow. For each coil, the directly measured ultrafiltration rate was a linear function of the mean coil pressure. Three or more measurements of ultrafiltration rate at different mean coil pressures always fell on or very close to a straight line. Fig. 1 shows the mean intercepts of these lines at 100, 200, and 300 mm Hg for each coil type. Each coil type exhibited a characteristic relationship with only slight variation between coils. The relationship of ultrafiltration rate to mean coil pressure was similar for UF-145, EX-01, and UF-100 cupraphane coils, EX-03 coils had significantly higher mean ultrafiltration rate intercepts than did other coils at mean coil pressures of 200 and 300 mm Hg ($P < 0.01$, non-paired t analysis).

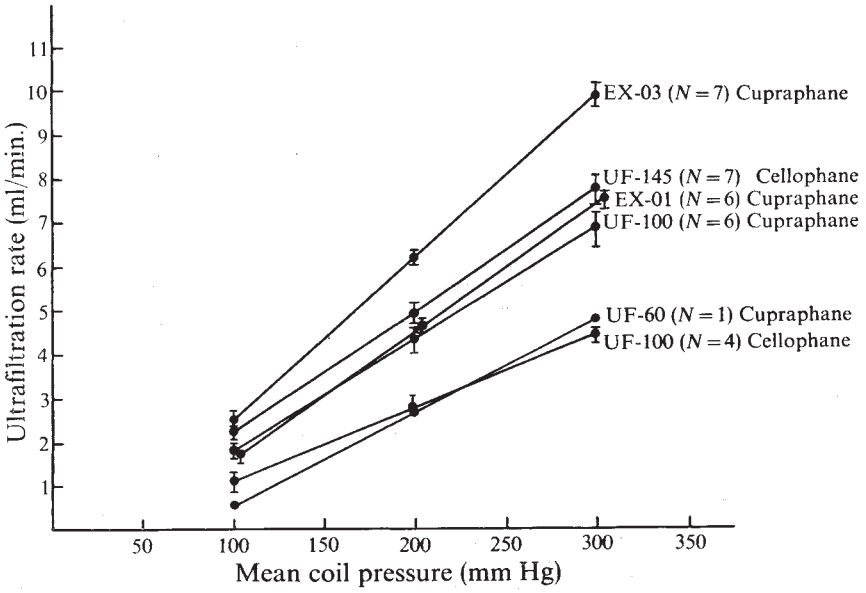

Fig. 1. The mean (± SEM) intercepts of directly measured ultrafiltration rate (vertical axis) are shown at 100, 200, and 300 mm Hg mean coil pressure (horizontal axis) as calculated from the number of lines designated for each coil type.

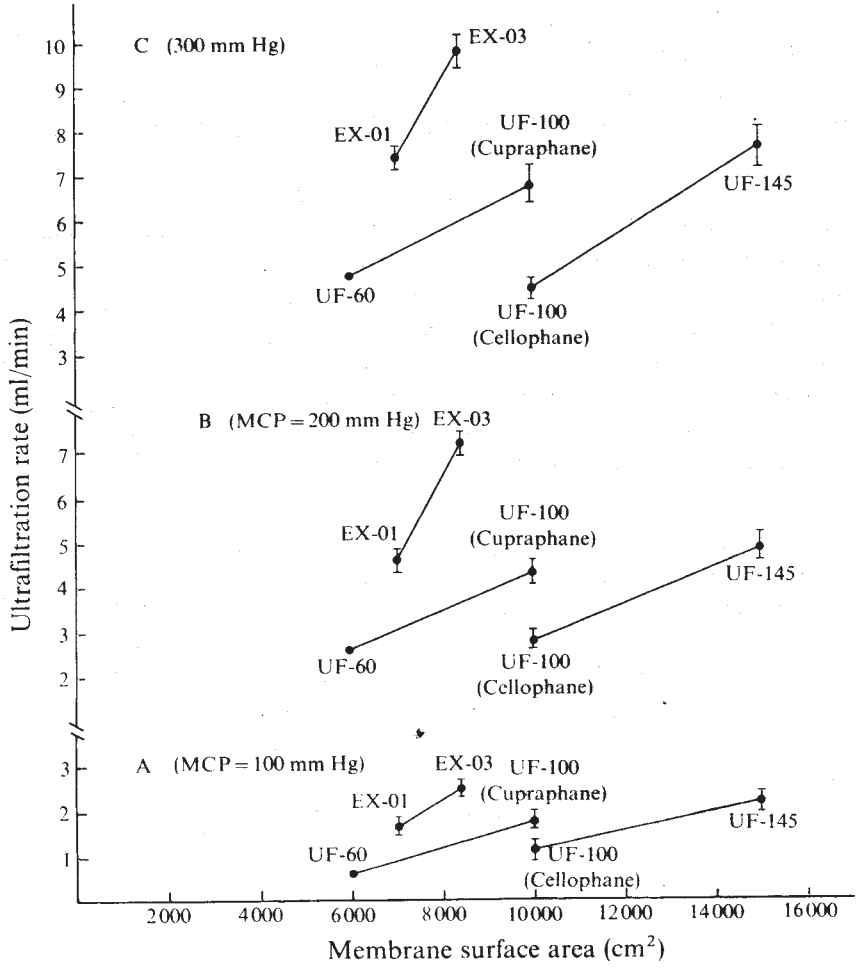

Fig. 2. The mean (± SEM) intercepts of directly measured ultrafiltration rate (vertical axis) as shown in Fig. 1 are related to coil membrane surface area (horizontal axis) at 100, 200, and 300 mm Hg mean coil pressure (A, B, and C respectively).

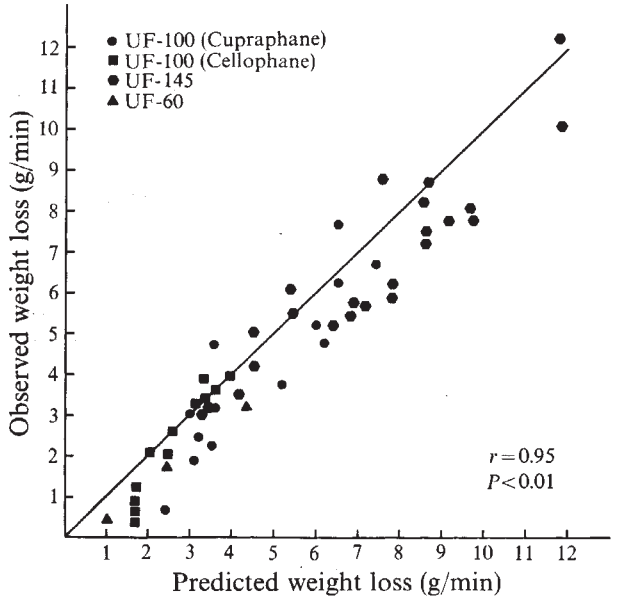

Fig. 3. The relationship of observed net weight loss (vertical axis) to predicted net weight loss (horizontal axis) is shown for all clinical studies using UF coils.

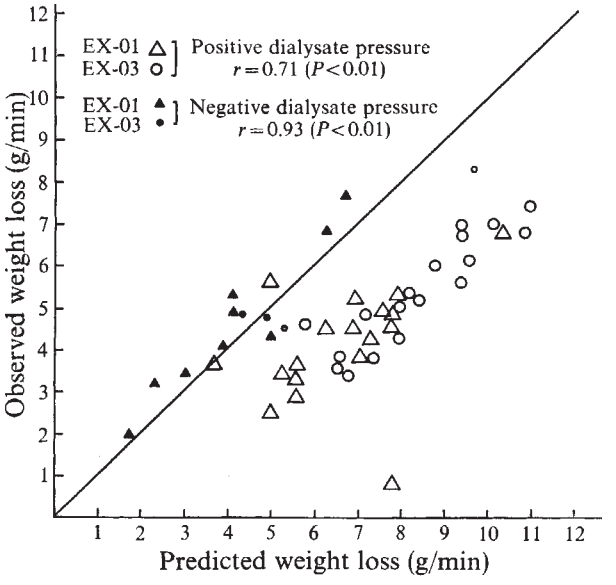

Fig. 4. The relationship of observed net weight loss (vertical axis) to predicted net weight loss (horizontal axis) is shown for all clinical studies using EX coils with either positive (open symbols) or negative (closed symbols) dialysate pressure.

In contrast, UF-100 cellophane coils yielded mean ultrafiltration intercept values significantly below those of other coils at 200 and 300 mm Hg ($P<0.01$). Intercept values in a single UF-60 coil were also relatively low at these mean coil pressures. Fig. 2 relates the mean intercept values of ultrafiltration rate at 100, 200, and 300 mm Hg mean coil pressure (Fig. 1) to membrane surface area. It is apparent that the mean ultrafiltration rates of all coils was not linearly related to membrane surface area. The mean values for UF-100 (cellophane) fall below the mean values for UF-100 (cupraphane) coils at each level of mean coil pressure. Similarly, mean values for EX-01 and EX-03 fall above values for UF coils relative to surface area.

The relationship of net weight loss to mean coil pressure. Mean basal weight loss from overnight fasting was $0.66 \pm$ SEM 0.06 g/min and varied little in given patients. In several patients post-dialysis values were found to be similar to predialysis measurements. Fig. 3 shows the relationship of predicted net dialysis weight loss to the actual observed net weight loss values for each UF coil. Since the linear relationship of ultrafiltration rate to mean coil pressure *in vitro* varied slightly among coils of a given type (Fig. 1), observed weight loss was related to the value predicted from the studies in a particular coil rather than from mean values for a coil type. This should provide a more precise analysis of deviations from direct *in vitro* measurements during dialysis. In Fig. 4, a similar relationship for EX coils is shown. Note that for UF coils the values fall close to the identity line and are highly correlated ($r=0.95$, $P<0.01$). In contrast, the values for the EX coils where positive dialysate pressure was used (Fig. 4, open symbols) for the most part fall several g/min below the identity line, but are still significantly correlated ($r=0.71$, $P<0.01$).

The mean difference for the net dialysis weight loss (g/min) and directly measured ultrafiltration rate (predicted net weight loss in g/min) at identical mean coil pressures for each coil type using positive dialysate pressure was: UF-145, $-0.6 \pm$ SEM 0.2 g/min; UF-100 cupraphane, $-0.5 \pm$ SEM 0.3; UF-100 cellophane, $-0.3 \pm$ SEM 0.1; UF-60, $-0.7 \pm$ SEM 0.1; EX-01, $-2.5 \pm$ SEM 0.4; EX-03, $-3.1 \pm$ SEM 0.2. The absolute magnitude of the difference was significantly greater for EX coils than for UF coils ($P<0.01$ level by non-paired t analysis).

Fig. 4 also shows the relationship of predicted to observed net weight loss during the 13 EX coil studies with negative dialysate pressure (closed symbols). Values fall close to the identity line and the mean values of observed minus predicted weight loss were $-0.48 \pm$ SEM 0.45 and $+0.45 \pm$ SEM 0.18 for EX-03 and EX-01 coils, respectively. In nine of 13 studies observed, weight loss exceeded the predicted amount.

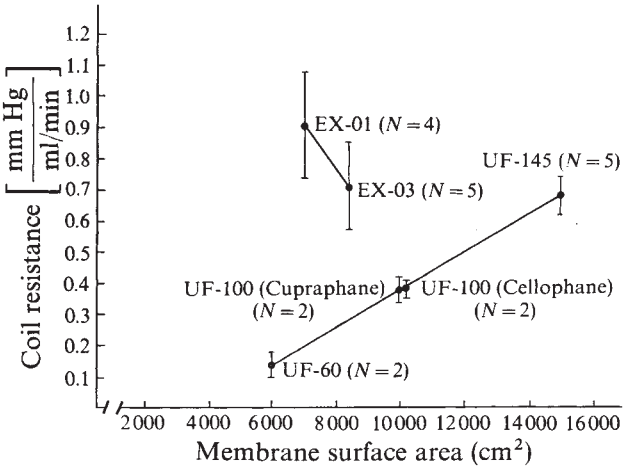

Fig. 5. Mean (± SEM) coil resistance values (vertical axis) for the various coil types are related to coil membrane surface area (horizontal axis). Resistance was measured when coils perfused with 0.9% NaCl at 25° C, a perfusion rate of 200 ml/min, and an outlet pressure of 200 mm Hg.

The osmolality of the inflowing dialysate ranged from 262 to 289 mOsm/kg H_2O while arterial osmolality varied from 280 to 328 mOsm/kg H_2O. The dialysate glucose concentration was 200 mg/100 ml in all studies. Arterial minus dialysate osmolality ranged from −3 to +56 mOsm/kg H_2O. The observed minus predicted net weight loss values for EX coils tended to fall below those of UF coils over a wide range of arterial dialysate osmolality gradient. The range of observed minus predicted net weight loss values seen for UF coils was similar regardless of the arterial dialysate osmolality gradient. In EX coils the deviations of observed weight loss from predicted values were not explained by osmolality gradients.

Comparison of coil resistances under comparable conditions. Values of coil resistance under identical conditions, as related to membrane surface area, are shown for each coil type (Fig. 5). For UF coils, mean resistance increased linearly and significantly ($P<0.05$, non-paired t analysis) with each increment in membrane surface area. In contrast in the EX coils, mean resistance did not change significantly as membrane surface area increased. EX-01, EX-03, and UF-145 were the higher resistance coils while the UF-60 was very low. UF-100 coils were in between these extremes. In the samples studied, resistance was more variable in EX than in UF coils. In UF coils, dialysate circulation had essentially no effect on manometer readings and, therefore, on resistance. In contrast, resistance increased by 25% when dialysate was circulated through EX coils.

Discussion

In any given coil during dialysis, mean coil pressure is a function of inlet and outlet pressure. At a fixed outlet pressure, inlet pressure is determined by blood flow rate, coil resistance and blood viscosity (protein concentration, temperature, and hematocrit) [1]. Prediction of mean coil pressure and, therefore, ultrafiltration rate is not possible unless all the variables are controlled or mean coil pressure is measured directly.

Differences in clinical ultrafiltration performance of respective coil types relate in part to the mean coil pressures at which each tends to operate at given blood flows and outlet pressures as a function of its own resistance. The increase in the resistance of UF coils as membrane surface area increases (Fig. 5) may be related to the progressive increase in tubular length (Table 1). In contrast, a slight decrease in resistance in EX coils as membrane surface area increases is not an unexpected result of increasing tubular width. The variations in resistance within coil types (as shown by the standard errors in Fig. 5) add to the difficulties of comparing and predicting ultrafiltration rates for different coil types from outlet pressure regulation alone, and again emphasize the advantage of monitoring mean coil pressure.

Cestero and Freeman [2] compared the resistances of UF-145, EX-01, and UF-100 cupraphane coils under fixed conditions and found values similar to ours. Ultrafiltration rates were compared *in vitro* at identical outlet pressures rather than at the same mean coil pressures, and predictions of *in vivo* performance were not attempted [2]. Perfusate temperature and hematocrit were not specified. Black [3] and Holmes and Nakamato [4] developed graphs from *in vitro* data to predict dialysis weight loss from outlet pressure for standard coils. Effects of large variation in blood flow and/or blood viscosity were not assessed. The hematocrit and temperature of the blood used to generate *in vitro* data were not specified.

On respective nomograms, Lowrie, Hampers, and Merrill [5] related *in vitro* ultrafiltration rates for UF-145 and UF-100 cupraphane coils to outlet pressure and blood flow at fixed perfusate hematocrit of 25 to 30 vol.-%. Perfusate temperature was not specified. Inlet pressures and mean coil pressures were measured but not incorporated directly into the nomograms. Variations in coil resistance within each type were neglected in the development of the nomogram. Nevertheless the nomograms permitted good prediction of dialysis weight loss within the limits of

the slight variations of variables that affect mean coil pressure. Greater ultrafiltration rates in UF-145 than UF-100 cupraphane coils were attributed to the greater resistance and usually higher coil pressures in the former rather than differences in ultrafiltration at comparable mean coil pressures. This is in accord with our findings, since UF-145 and UF-100 cupraphane coils have similar ultrafiltration rates at identical mean coil pressures (Figs. 1 and 2). Other coils were not studied.

In a previous report [1], we showed that directly measured ultrafiltration rate *in vitro* was a linear function of mean coil pressure in UF-145 coils. The present study demonstrates that direct measurement of ultrafiltration rate in different types of coils under identical conditions gives comparable results and that there exists such a linear relationship, with distinct differences in the slope, for all coil types. These differences reflect at least three variables. First, the total surface area of membrane is an important factor and probably explains the differences in ultrafiltration rate between EX-01 and EX-03 coils and between UF-145 and UF-100 cellophane coils (Fig. 2). The differences between the coils in each of these pairs represent essentially only the membrane area since the coil structure and membrane type are identical. Secondly, the cupraphane in the tested coils demonstrates greater ultrafiltration capacity than cellophane. This is shown by the greater ultrafiltration rate in UF-100 cupraphane coils as compared to UF-100 cellophane coils which are otherwise identical in structure and membrane surface area. The fact that the UF-145 values are below the predicted line in the UF cupraphane coils (Fig. 2) also supports this contention. Previous work under different study conditions [6] indicated better ultrafiltration capacity with cellophane than with cupraphane coils. It is recognized that cupraphane lots show different properties due to variations in manufacturing conditions. Nevertheless, these studies show that membrane characteristics are also an important determinant of ultrafiltration. Thirdly, coil structure itself may affect ultrafiltration values (Fig. 2) by the tendency of EX coils to yield values above those seen with UF-100 cupraphane coils, despite a greater membrane surface area in the latter. Such differences might be attributed to differences in mesh support effects or to the possibility that cupraphane may not be comparable even though it is the same thickness (Table 1).

It has previously been shown that perfusate temperature and protein concentration affect the relationship of ultrafiltration to mean coil pressure [1]. The problems with predictions of *in vivo* coil performance from values obtained in the laboratory with protein-free perfusate at room temperature have been avoided in the present study. Both the direct ultrafiltration measurements and the determination of weight loss during clinical hemodialysis were accomplished in each coil while perfused with the same blood at body temperature. Variations in temperature and protein concentration from patient to patient should cause little deviation from the relationships shown.

The results of the present study show that net weight loss during dialysis can be predicted almost directly from mean coil pressure for UF coils. Mean predicted minus observed values for net weight loss with the four types of UF coils ranged from -0.3 to -0.7 g/min. Although with EX coils the observed net weight loss was significantly less than the predicted values (mean differences ranging from -2.5 to -3.1 g/min), these differences varied little for each coil type and an accurate prediction was thus permitted by subtracting the mean difference from the predicted values.

The scatter of the data in Figs. 3 and 4 may reflect some methodological errors and/or some variations in the effect of dialysate hydrostatic pressure (see below). It is impossible to compare the scatter of these data with that of other techniques for predicting weight loss. In most previous studies, it is not clear which of the many variables affecting the mean coil pressure were rigidly controlled. In our study blood flow rate, outlet pressure, and hematocrit did not need to be controlled or confined to any given combinations to predict weight loss.

Two factors might account for the differences between predicted and observed weight loss. With dialysate circulation relatively higher, blood osmolality and/or significant dialysate hydrostatic pressure could counteract the effects of the hydrostatic pressure within the blood path. In the present studies, arterial and bath osmolality differences varied over an even greater range for UF coils than EX coils, and osmolality differences were not sufficient to explain the variation of observed minus predicted weight loss. Osmolality differences were primarily attributable to the serum urea nitrogen concentration and they were probably dissipated by the movement of urea from blood to bath with little effect on net water movement. The mean effective osmotic gradient should be less than the arterial inflow/dialysate gradient and would explain the minimal effect noted. Greater osmolality

differences can cause a greater midcoil effective gradient and thus can significantly affect net ultrafiltration rate [4, 7], particularly if due to large solutes such as glucose. Probably more important than dialysate osmolality in our studies, however, is the fact that dialysate hydrostatic pressure has been measured in the laboratory as high as 56 to 146 mm Hg in the small encased EX coil[1]. This is supported by the fact that the resistance of EX coils during dialysis was increased by the flow of dialysate while UF coils were not affected. The clinical ultrafiltration rate values at given mean EX coil pressures are about 2.5 to 3.0 ml/min less than those demonstrated *in vitro* without flowing dialysate (the mean observed-predicted values). Thus, in EX coils actual clinical ultrafiltration values relate to mean coil pressure values approximately 50 mm Hg lower than those predicted from ultrafiltration rate values. This approximate difference in mean coil pressure required to achieve a given ultrafiltration rate corresponds with dialysate hydrostatic pressure values which have been measured in these coils (see footnote 1) and could account for the relatively fixed difference between observed and predicted weight loss. In addition, when dialysate was pulled through EX coils by negative pressure, the observed weight loss usually exceeded that predicted. We did not attempt to measure dialysate hydrostatic pressure during clinical dialysis since a safe and acceptable technique is not available. The reported values and the cited observations provide presumptive evidence of the effects of dialysate pressure on EX coils. Measurements of dialysate hydrostatic pressure in UF coils were not available. Although dialysate hydrostatic pressure in UF coils could explain the small differences between predicted and observed net weight loss, our findings suggest lower pressures than in EX coils.

During clinical dialysis mean coil hydrostatic pressure appears to be the only significant determinant of ultrafiltration rate in UF coils. It is the dominant factor in EX coils. Thus, once mean coil pressure is determined, ultrafiltration rate within a narrow range of variation can be predicted for each coil type if perfused with blood at physiologic protein concentrations and temperature. Net weight loss during dialysis can also be predicted for all coils. With UF coils, directly measured ultrafiltration rate and net weight loss rate are nearly identical. Net weight loss in EX coils is usually 2.5 to 3 g/min less than predicted from directly measured ultrafiltration rate at an identical mean coil pressure, most likely reflecting an effect of dialysate hydrostatic pressure.

[1] Miller, F.: Extracorporeal Medical Specialties, Inc. Verbal communication.

Acknowledgements

This work was supported in part by Clinical Research Center Grant RR-00287-04 and the University of Missouri Kidney Research Fund. We appreciate the assistance of Mrs. Miriam David, R. N., Head Nurse Clinical Research Center, and the Clinical Research Center Nursing Staff. We acknowledge the technical support of Mrs. Kathleen Schneider and secretarial efforts of Mrs. Teresa Nothum.

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